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THE LABOR MARKET CONSEQUENCES OF ELECTRICITY ADOPTION: CONCRETE EVIDENCE FROM THE GREAT DEPRESSION

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Keywords: electricity, technical change, Great Depression, labor market, employment, labor productivity, labor share of income.

JEL codes: J24, N12, N62, O33.

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1 Introduction

A long-standing question in economics is whether labor-saving technology affects firms in the medium-term by increasing output, decreasing employment, or both. The debate on labor displacement seems to revive from each new wave of technology adoption: the Jacquard textile loom, the steam engine, electricity, and computers. On the one hand, proponents argue that either firms do not pass on lower production costs as lower prices, or that demand adjusts slowly to lower output prices. Labor-saving innovations improve labor productivity faster than demand for products and are bound to displace some types of workers in the medium-term (i.e., over a 5-10 year horizon).[1] This view of unemployment caused by adoption of technologies came to be known as "technological unemployment." On the other hand, critics argue that firms do pass on lower production costs as cheaper prices and that demand for products adjusts quickly to those prices. The effect of productivity-enhancing technologies should occur at the output margin with firms increasing production instead of destroying jobs.[2] This view labels technological unemployment as the "Luddite fallacy." The debate has again resurfaced in the context of computers, e.g. with computers leading firms to create more narrow job opportunities by skill and permanently increasing unemployment and the skill premium (Acemoglu, 1999), and especially with the high unemployment since the Great Recession of 2007 (Jaimovich and Siu 2012;Krugman, 2013;Frey and Osborne 2013). Despite the length of the debate and the relevance of occupational displacement for policymakers since the financial crisis of 2007, there is little empirical work supporting either side of the discussion.[3]

This paper uses Instrumental Variables methods to test the theory of technological unemployment and identify the causal effects of labor-saving technology. Focusing on the adoption of electricity in the concrete industry during the 1930s for its unique source of variation and data availability, it finds that firms adjusted to this labor-saving technology by decreasing employment rather than increasing output. The first contribution of this paper is a new geographical instrument—coal burning or hydroelectric power in the generation of electricity—for the change in the price

[1]See Ricardo (1821), Mill (1871), Keynes (1933), and Samuelson (1988).

[2]See McCulloch (1821), Wicksell (1923), Say (1924), and Woirol (1996, pages 17-18).

[3]Lubin (1929) surveyed over 700 recently laid off workers in Baltimore, Chicago, and Worcester and documented their difficulty in finding a new job. Jaimovich and Siu (2012) show descriptive statistics that occupations susceptible to replacement by computers suffer more after recent recessions.

of electricity in the United States in the 1930s. To maximize the chances that the exclusion restriction holds, the paper uses labor market measurements from the concrete industry because it is a local, non-traded industry whose location decisions are driven by proximity to customers and in principle orthogonal to the geographic instrument.[4] The second contribution is to use a plant-level dataset for the concrete industry from 1929 to 1935 digitized for the first time for this project. This paper uses a 2-Stage Least Squares approach to first establish that electricity was a labor-saving technology: cheaper electricity caused an increase in electric capital intensity and in labor productivity, as well as a decrease in the labor share of income. The paper then tests the margin of adjustment and finds that firms increased labor productivity by reducing employment instead of increasing output. These results are robust to including a range of geographic and plant-level controls.

Studying the adoption of electricity in the concrete industry in the 1930s provides unique features to examine the margin of adjustment to a labor-saving technology. Two challenges arise in this context: the source of variation determining technology adoption and the available data on productivity, capital intensity, employment, and output. The 20th century witnessed two main General Purpose Technologies: computers and electricity (Field, 2011). Computers have limited price variation within a country and it is inherently difficult to control for all idiosyncrasies at the national level in a comparison across countries. On the other hand, electricity before 1950 not only has price variation across regions but also offers an instrument with the generating technology (hydroelectric power or coal power). The plant-level dataset that survived over this period, the Census of Manufactures from 1929 to 1935,[5] is unique in that it contains information on employment, wages, output by quantity and value, and the horsepower of electric motors. This context warrants a test of the transmission mechanism of cheaper electricity and its effects on output and employment.

To guide empirical work, the paper proposes a simple model of technology adoption where firms

[4]See Syverson (2004) and other papers cited in Section 2.

[5]Bresnahan and Raff (1991) was the first paper to use this dataset at the micro-level to describe how the automobile industry weathered the Great Depression. Ziebarth (2011), Ziebarth, Chicu and Vickers (2013), Ziebarth and Mathy (2014) renewed interest in this dataset and digitized other industries to answer questions on the dispersion of Total Factor Productivity across plants, collusion agreements during the National Recovery Act, and the employment effects of political uncertainty under Huey Long. See Appendix A.3 for details on the Census of Manufactures in other years.

can substitute repetitive, manual tasks with electrical machinery. The model predicts that cheaper electricity increases productivity and capital intensity. In addition, if the elasticity of substitution is sufficiently large (greater than one), the model also predicts that cheaper electricity decreases the labor share of income. The test of these predictions inform whether electricity was a labor-saving technology. In a second set of more intuitive predictions, the paper asks whether plants adjust to cheaper electricity by increasing output or by decreasing employment.

To address endogeneity bias, this paper uses an Instrumental Variable approach. A natural concern would be that a positive aggregate demand shock can simultaneously increase the price of electricity and the demand for concrete products. The resulting correlation between electricity and output is not due to the channel of technology adoption in question. To avoid bias from demand shocks and other omitted variables, this paper uses the coal share of power as an instrument for supply-side changes in the price of electricity. Electricity came from two main sources in the 1930s: hydroelectric power and coal power. Hydroelectric power was relatively efficient from the start and extracted 90% of the potential energy of falling water, leaving no margin for progress. Coal power was relatively inefficient, it extracted 25% of the thermal energy of coal, and this technology improved for exogenous reasons (an increase in steam pressure and the addition of a second steam circuit). States with coal power, such as New Jersey, need to pay initially more for electricity, but the price of electricity falls faster than states with hydroelectric power, such as California. The first stage of the regression consists of instrumenting the change in the price of electricity over 1927-1937 with the initial level of coal reliance in 1927.

The second stage of the 2SLS approach consists of running regressions with the labor market outcomes from the non-traded industry of concrete, digitized for the first time for this project. Given the geographical variation in electricity prices, it could still be a problem if firms could endogenously choose where to locate their business. The concrete industry, being a non-traded industry with high transport costs, provides a close approximation to a random allocation of plants across regions. (The concrete industry is the 6th most dispersed industry according to a Gini concentration index.) The second stage of the regression uses as outcome variables the plant-level measurements of the labor share of revenue, labor productivity, electric capital intensity, employment, and output.

The baseline results in Instrumental Variables confirm that electricity was an important labor-saving technology: technological convergence of coal states to hydroelectric states caused a 11% decline in the labor share of income, a 36% increase in labor quantity productivity, and a 39% increase in electric capital intensity. The results also provide support for the technological unemployment hypothesis: cheaper electricity caused a 21% decrease in employment with no statistically significant effect on output, either in quantity or value. Technological convergence in electric utilities can explain up to 80% of job losses in the concrete industry during the Great Depression. These results are consistent with the view that the adoption of labor-saving technology causes job loss in the adopting sector. These results are robust to controlling for the housing boom in the 1920s, bank failures in the 1930s, unionization rates, proximity to dam construction, initial productivity, and initial size.

Related literature. This paper relates to two main strands of the literature: the theoretical and empirical effects of technological change and electrification during the 1930s.

From the large literature on the effects of technological change, this paper is most closely related to Acemoglu (1999), who suggests theoretically that Information Technologies change the process of job creation for firms: instead of creating jobs in a common pool aimed at both skilled an unskilled workers, they design jobs specifically for skilled and unskilled workers. The narrower scope of job vacancies permanently increases unemployment. This paper is also related to Jaimovich and Siu (2012), who find theoretically that the long process of routine-biased technical change led to the disappearance of middle-skill jobs during recent recessions. Autor, Levy and Murnane (2003) detail the empirical link between skills and technological change: using the Dictionary of Occupational Titles, the Census of Population and the Current Population Survey, they find that computerization substitutes for workers performing routine, cognitive tasks and complements workers performing nonroutine tasks. Hanlon (2011) tests the models of directed technical change by studying the increase in the price of American cotton due to the US Civil War and finding that British innovation was directed to take advantage of Indian cotton, which became relatively more abundant. He also finds evidence for the strong induced-bias: the relative price of Indian cotton *increased* after an initial decline, suggesting that the increase in demand for Indian cotton from those inventions more than offset the initial decrease in price. Perhaps closest in spirit to this paper, Hornbeck and Naidu (2014) use the Great Mississippi flood of 1927 as a natural experiment to estimate the effect of cheap labor on the mechanization of the agricultural sector. Massive out-migration and labor scarcity in flooded counties induced faster mechanization compared to similar nearby non-flooded counties. Compared to this literature on the effects of input prices on the demand for factors, this paper provides causal evidence by exploring the idiosyncrasies of historical electricity prices and asks whether firms adjust to cheaper technology at the output or employment margin, which is more difficult to assess with the confounding shifts in labor supply due to migration of workers.

On electrification in the 1930s, several studies have used aggregate-level data or Ordinary Least Squares to assess the effects of electrification on the labor market. Gray (2013) studied worker-level evidence from the first half of the 20th century and found that electrification was correlated with a shift away from occupations intensive in dexterity skills, similar to the findings of Autor, Levy and Murnane (2003) for computerization in the late 20th century. Field (2003) used aggregate-level growth accounting and argued that the 1930s had an unprecedented increase in TFP and were the "most technologically progressive decade of the century" because of electricity. Woolf (1984) used industry-level data from the Census of Manufactures between 1909 and 1929 and found that "firms sought labor-saving and capital-using techniques in response to cheaper energy ... [and reduced] labor's share of income." The evidence from previous studies is consistent with the thesis of this paper, whose contribution is to use plant-level data, to propose a new instrument for the adoption of electricity, and to fully test the implications of technology adoption on the labor share of income, employment, productivity, and capital intensity. Also on electrification, Severnini (2012) uses a related but distinct instrument: among all counties in the US with high hydroelectric potential, he compares counties that received dam construction to those that did not. He finds strong and persistent effects of dam construction: a dam built before the 1950 causes an increase in the county's population density of 51% after 30 years. Our instruments are different in that he uses dam construction within high hydroelectric potential counties and this paper uses a comparison between hydroelectric power and coal power. The papers are also different in that he looks at the long-run effects on population density over the

20th century while this paper looks at mechanization, labor share, productivity, and employment within the firm.

The remainder of the paper is organized as follows. Section 2 discusses the data sources. Section 3 presents a simple model of technology adoption. Section 4 presents the identification strategy and the results on labor-saving technology and the margin of adjustment. Section 5 concludes.

2 Data

This section presents the reasons for focusing on the concrete industry, describes the industry background and the micro-data, and details the production of electricity as well as the data sources for the price of electricity.

2.1 Motivation for the concrete industry

Similar to previous literature, this paper uses the concrete industry as an empirical laboratory for the wider economy: for example, Hortaçsu and Syverson (2007) used it to study the effect of vertical mergers on market power. This paper uses the concrete industry for two reasons: the identification strategy and the transition from manual power to power from the grid.

The main reason to choose the concrete industry is non-tradability and spatial dispersion (Syverson, 2004): downstream of the cement industry, it produces heavy products with high transport costs or a limited time to reach its destination (e.g., ready-mix concrete has to be delivered in a few hours before it hardens).[6] Accordingly, concrete is among the most spatially dispersed industries with a Gini concentration coefficient of 29% in 1929.[7] The non-traded quality of concrete products ensure that this industry locates near its customers, as opposed to industries selling traded goods and able to choose their location. Concrete plants locate in New Jersey

[6]The cement industry heats limestone to produce cement, which the concrete industry uses to manufacture heavy products, such as concrete slabs. Cement is a traded product and this industry is more concentrated with a Gini concentration coefficient of 82%.

[7]This coefficient (Holmes and Stevens, 2004, page 2810) measures the difference between the distribution of economic activity compared to population. The most dispersed of all industries is Beverages with a Gini concentration coefficient of 16%.

or California to be close to their customers—which strengthens the exclusion restriction of the identification strategy in Instrumental Variables.

A second reason to consider the concrete industry is the analysis of the transition from manual power to electricity powered by the grid. The concrete industry has the advantage of consisting of small plants that buy all of their electricity from the grid. With around 13 employees, concrete plants may not afford to have steam engines or electric generators on site. In contrast, the manufacturing industry is four times larger with 48 employees per plant[8] and was more suited to afford the fixed costs of on-site electric generators, using 35% of its electric horsepower with electricity generated in the plant. This paper focuses on the transition from manual labor to electric-powered machinery and avoids the switch from one type of power technology to another. The concrete industry provides a clean setting: 99.99% of electric horsepower and 90% of all horsepower is driven by electricity purchased from the grid—the highest of all non-traded industries.[9]

For these reasons, a detailed case study of the concrete industry is a clean setting to estimate the effects of electricity adoption on firm's labor decisions. The broader economy is more complex and identification is not as clean because of geographical sorting, the endogenous choice of the generation of power, and strategic adoption. But anecdotal evidence on the wider adoption of labor-saving machinery in the 1930s suggests that the effects of cheaper electricity could be more general than what can be found in the concrete industry: Jerome (1934) compiled an extensive list of labor-saving innovations in other industries and the House of Representatives suggested in 1936 that "mechanical and other labor-saving devices are the chief cause of the growing number of unemployed."[10]

[8] Census of Manufactures, 1929, Table 3, page 16.

[9] Industries with a spatial concentration coefficient in 1929 below 30%.

[10] Committee on labor (1936, page 118)

2.2 Plant-level data for the concrete industry

The dataset used in the analysis is the Census of Manufactures in 1929 and 1935, which covers the universe of manufacturing plants with sales above five thousand dollars.[11] This dataset is at the National Archives and Records Administration in Washington D.C. Two barriers prevent the wider use of this dataset: the schedules are in paper or microfilm format and the National Archives protect them with in-house access only. The concrete industry was digitized for the first time for this project.

According to the Census Bureau, the concrete industry consists of "establishments engaged primarily in the manufacture of building materials, pipe and conduit, and commodities such as poles and piling, vaults, trays, etc., from a combination of stone or gravel, sand, and cement. The classification does not cover concrete construction work on buildings, bridges, etc." This definition is stable between 1929 and 1935. Note that the concrete industry is different from cement, which it uses as an input to produce heavier products such as concrete slabs.

I scanned all the microfilm schedules (around 2,500 for 1929 and 1,100 for 1935). The archivists marked as lost one microfilm roll with 300 plants in 1935 for states Alabama to Iowa but I was able to locate a backup copy in a different location.[12] A professional data entry firm tabulated these schedules into electronic format. I verified the tabulations and corrected outliers, such as missing commas in the separation of cents and dollars. I also cleaned the names of states, counties and cities. The Census Bureau had no unique plant identifier and I matched the plants across years based on their name, location and ownership (see Appendix A.3). From the 3,500 plants present in both 1929 and 1935, I obtained a panel of 630 continuing plants.

The dataset also has information on employment, wage-bill, revenue, the quantity of concrete tons, and the horsepower of electric motors, which serve as outcomes in the investigation of the effects of cheaper electricity. Table 1 shows summary statistics for continuing concrete plants in 1929. The concrete industry has many small plants, with an average of 13 employees. Table 2

[11]This threshold in 1929 corresponds to around $66 thousand today and is high above the average sales for the concrete industry of $38 thousand in 1929 prices.

[12]Despite scanning all the records I could find at the National Archives, some discrepancies remain between my sample and the state-level aggregation from the books published by the Census of Manufactures: some firms are missing from California in 1935, and the total value of products is sometimes different.

shows summary statistics for the change between 1929 and 1935. On average, concrete plants had a decrease in output, the labor share, employment, the price of electricity, and an *increase* in the horsepower of electric motors.

[TABLES 1-2 HERE]

The production of concrete consists of mixing cement, often portland cement, with water and an aggregate, e.g. crushed stone, sand, or gravel. Some concrete plants are also quarries and may source the stone on site, otherwise they buy the aggregate. Plants mix the ingredients to obtain a fluid substance poured into a mold, which hardens with time. Plants sometimes vibrate the mold to achieve a more compact product. They cure the concrete product with water, as cement requires a moist environment to harden further and increase strength. Plants may also polish the concrete product with sandblasting—a jet of water mixed with sand under high pressure to remove superficial irregularities. If plants convey the concrete product over a long distance to the delivery location, the product bears the risk of un-mixing (see Tennessee Valley Authority, 1947).

Concrete plants use labor-saving electrical machinery at several stages of production of concrete: Jerome (1934, page 137) mentions that "the power-driven concrete mixer has practically displaced hand mixing." Orchard (1962, page 404) concurs and mentions that "on all but very small jobs concrete is now mixed by machines because of the labour saved and the much more homogenous mix produced. If mixing is carried out by hand an extra 10 per cent of cement should be added to compensate for the reduced strength arising from the less than perfect mixing." Other examples of labor-saving inventions in the concrete industry are machines for crushing and grinding stones into a finer aggregate, machines for pumping and unloading units to convey cement, electric power shovels and conveyor belts or elevators to move materials, electrical curing machines and power surfacing machines, and waste-heat boilers (Jerome, 1934, page 80).

The most common products in the sample of continuing concrete plants are building materials, which represent 48% of value in 1929 (especially "Block and tile," which represent 24% of value) and "Conduits and pipes", which represent 23% of value (especially reinforced sewer pipe, which represents 11% of value). These most common products suggest that the construction sector and the population at large are the main customers of the concrete industry. The population's location decisions are slow-moving and likely to be unrelated to the geography of electricity prices, avoiding co-location problems between the customers of the concrete industry and cheap electricity.

This paper considers the income $p_{i,t}Y_{i,t}$ to be revenue instead of value added. Revenue is a more robust measure and contains fewer outliers: for example, some plants during the Depression were operating at a loss and had negative value added.[13]

The concrete industry had a decline in the labor share of revenue of 14 percentage points, from 28.7% in 1909 to 14.4% in 1939, illustrated in Figure 1. Half of this decrease, or 7 percentage points, occurred during the Great Depression. The other half occurred during the other recessions of 1927 and 1937.[14]

[FIGURE 1 HERE]

This period covered is 1929 to 1935, the first half of the Great Depression. An important reason is that the plant schedules of the Census of Manufactures survived only for this period and the years before or after were destroyed. Access to plant-level data is important in order to link plants across years and avoid compositional bias due to the turnover of plants. It also contains more information, such as output in tons of concrete, the price of concrete products, and the horsepower of electric motors, which is not otherwise available. Another reason to focus on this period is that it is most relevant to test the theory of technological unemployment after a major recession with widespread joblessness.

2.3 Electricity data

The price of electricity decreased exponentially over the first half of the 20th century, as illustrated in Figure 2 from the Historical Statistics of the United States. The decrease in the real price of

[13] See Berman, Bound and Griliches (1994, page 383) for a similar approach.

[14] The labor share of value added shows similar numbers: a decline of 17 percentage points from 46% in 1909 to 29% in 1939, of which 7 percentage points occurred during the Great Depression. Nevertheless, this measure is less comparable across years because it sometimes omits fuel and energy.

residential electricity is 5.8% per year. The real price of electricity increased slightly during the Great Depression because of deflation in the consumer price index. In a more general context with irreversible investment, firms would have difficulty adjusting their capital stock to cyclical changes in the price of electricity and would react to the trend in the price of electricity rather than to the fluctuations. Furthermore, the nominal price of electricity decreased by 2% per year in the sample of concrete plants (see Table 2).

[FIGURE 2 HERE]

The technology to produce electricity from coal improved over the first half of the 20th century, but hydroelectric technology did not. The coal technology was relatively inefficient compared to hydroelectric power: "In generating electricity from coal even the largest and most modern electric power stations are able to utilize only about 25 per cent of the heat units available in the coal. ... On the other hand, modern hydro-electric machinery now transforms into electricity more than 90 per cent of the energy in falling waters, leaving little opportunity for radical improvements in present-day hydro-electric practice."[15] The generation of electricity from coal improved thanks to a "rise in steam pressures and steam temperatures used, and ... the experimental introduction of a second working fluid in an independent cycle supplementing that of the steam."[16] These innovations increased the thermal efficiency of fuel: "In 1928, the same amount of energy was produced with 71 per cent less fuel than would have been required in 1904."[17]

Hughes (1993) describes economies of scale as another source of technical progress. As an outcome of the development process, economies of scale are less likely to verify the exclusion restriction and are not used as an instrument in this paper. The interested reader is referred to his account of electrification in Western Society over the period 1880-1930.

This paper uses data at the state-level from the Census of Electric Light and Power Stations in 1927 and 1937, published by the Census Bureau. It uses total revenue divided by current sold to ultimate consumers as a proxy for the cost of electricity by state. The relevance of this

[15] National Electric Light Association (1931, page 47).

[16] Census of Electric Light and Power Stations (1927, page 82)

[17] Electrical Research Statistics (1929). See also Sleight (1930, page 57) for a similar finding.

proxy is supported by the state-level regulation of electric utilities, which constrain the ability of power stations to transfer electricity across states. Most utilities were regulated at the state-level: Stigler and Friedland (1962) document that 42 out of 48 mainland states had a state-level regulator by 1929.[18] In 1932, only 5.7 percent of electricity was purchased from electric utilities in other states (Census of Electric Light and Power Stations, 1932, page 14). Notice also that the public electricity projects come at the end of the sample period and are less likely to have a strong effect: the Tennessee Valley Authority started delivering power in 1934 (Kitchens, 2012), compared to the time period of 1929-1935 in the sample. The preferred measure of the change in the price of electricity in this paper is:

$$\Delta \log \left(p_{E,k,t}\right) = \frac{1}{10} \log \left(\frac{p_{E,k,1937}}{p_{E,k,1927}}\right),$$

where $p_{E,k,t}$ denotes the price of electricity for state k at time t, which is the average price of electricity for ultimate consumers from the Census of Electric Light and Power Stations in 1927 or 1937.

This paper also uses other sources during the Great Depression: county-level housing construction from Kimbrough and Snowden (2007), state-level price of cement from Ziebarth, Chicu and Vickers (2013), county-level deposit suspensions and a unionization index from Fishback et al. (2011).[19] This paper also uses Geographic Information Systems to compute the change in housing and in deposit suspensions in a radius of 50 miles around a county.[20]

3 A partial equilibrium model of technology adoption

This section presents a simple production function with capital-labor substitution and its implications for the labor share of income, labor productivity, and electric capital intensity. It

[18]The six unregulated states are Arkansas, Florida, Kentucky, Louisiana, Mississippi, and New Mexico. These states have little importance in the concrete industry and represent only 20 plants in the sample.

[19]Kenneth Snowden kindly provided the electronic data for the housing boom; deposit suspensions are from Price Fishback's website, accessed on 9 December 2014; Nicolas Ziebarth kindly provided the data from the cement industry.

[20]The calculations in Geographic Information Systems are available upon request.

also translates these predictions into regression equations and adds further tests on the margin of adjustment—whether firms adjust to growing productivity by increasing output or firing workers.

3.1 A simple model

Plants are indexed by i and produce output $Y_{i,t}$. Plants hire workers to perform two types of tasks, routine tasks $L_{R,i,t}$ and nonroutine tasks $L_{NR,i,t}$. Plants also rent two types of capital, non-electric capital $K_{NE,i,t}$ and electric capital $K_{E,i,t}$. The production function is the most important part of the model.

Assumption 1. *The production function for plant i is:*

$$\begin{aligned} Y_{i,t} &= A_{i,t}\; K^{\alpha}_{NE,i,t}\, L^{\beta}_{NR,i,t}\, M^{1-\alpha-\beta}_{i,t}, \\ M_{i,t} &= \left(K^{\frac{\sigma-1}{\sigma}}_{E,i,t} + L^{\frac{\sigma-1}{\sigma}}_{R,i,t} \right)^{\frac{\sigma}{\sigma-1}}, \end{aligned} \tag{1}$$

where $A_{i,t}$ is Total Factor productivity and σ is the elasticity of substitution between routine tasks and electric capital.

This production function has Cobb-Douglas aggregation of three factors: non-electric capital $K_{NE,i,t}$, employment in nonroutine tasks $L_{NR,i,t}$, and a third factor, which is a Constant-Elasticity-of-Substitution aggregate between electric capital $K_{E,i,t}$ and employment in routine tasks $L_{R,i,t}$. Krusell et al. (2000) use this production function to explain the increase in income inequality with capital-skill complementarity. They estimate an elasticity of substitution between capital equipment and unskilled labor at 1.67. Then the increase in capital investment contributes to increasing the skill premium by raising the marginal product of skilled labor faster than that of unskilled labor. Autor and Dorn (2009, page 11) also use this function to explain the recent disappearance of middle-skill, routine occupations: as firms invest more in computer capital, they increase employment of middle-skill routine jobs slower than low-skill or high-skill nonroutine jobs.[21]

[21] This production function is also related to the literature on directed technical change (Acemoglu, 2009, page

The firm takes prices as given and maximizes intertemporal profits:[22]

Assumption 2. *Plant i operates under perfect competition and maximizes the present value of profits, discounted with the market interest rate r_t. The profit flow of period t is:*

$$\textit{profits}_{i,t} = p_{i,t}Y_{i,t} - w_{NR,i,t}L_{NR,i,t} - w_{R,i,t}L_{R,i,t} - r_{NE,i,t}K_{NE,i,t} - r_{E,i,t}K_{E,i,t},$$

where $p_{i,t}$ is the price of output, $w_{NR,i,t}$ is the wage for nonroutine tasks, $w_{R,i,t}$ is the wage for routine tasks, $r_{NE,i,t}$ is the rental rate of non-electric capital, and $r_{E,i,t}$ is the rental rate of electric capital.

These assumptions on the production function and firm behavior have precise implications for ratio variables: the labor share of income, labor productivity, and electric capital intensity. These ratios correspond to total employment and do not differentiate between routine and nonroutine tasks. The focus on variables aggregated for all occupations stems from the Census of Manufactures, which does not report employment or wages by occupation (see Appendix A.3). The following proposition derives the implications of the production function for ratio variables (see Appendix A.1 for the proof).

Proposition 3. *Profit maximization under perfect competition implies the following expressions*

501): the ratio of marginal products of nonroutine and routine tasks is proportional to $1+(K_{E,i,t}/L_{R,i,t})^{\rho}$ and rises with electric capital, so the adoption of electricity favors non-routine tasks more than routine tasks. Nevertheless, this paper looks at the response of factor intensities as a function of relative prices, while the directed technical change literature looks at endogenous technological progress in the productivity of those factors.

[22]The assumption of perfect competition finds support in the concrete industry: in 1929, less than 5% of all concrete plants are in a state with fewer than five competitors, and less than 2% of plants with fewer than three competitors. Bresnahan and Reiss (1991) find that three to five competitors is sufficient to induce competitive behavior. The small scale of concrete diminishes the importance of strategic technology adoption, whereby an oligopolist may have an incentive to adopt a technology earlier to front-run a competitor or later to benefit from cheaper future prices (Tirole and Fudenberg, 2010, Reinganum, 2007).

for the labor share of income, labor productivity, and electric capital intensity:

$$\frac{w_{i,t}L_{i,t}}{p_{i,t}Y_{i,t}} = \beta + \gamma \left(1 + \left(\frac{r_{E,i,t}}{w_{R,i,t}}\right)^{1-\sigma}\right)^{-1}, \tag{2}$$

$$\frac{Y_{i,t}}{L_{i,t}} = \frac{w_{i,t}}{p_{i,t}} \left(\beta + \gamma \left(1 + \left(\frac{r_{E,i,t}}{w_{i,t}}\right)^{1-\sigma}\right)^{-1}\right)^{-1}, \tag{3}$$

$$\frac{K_{E,i,t}}{L_{i,t}} = \left(\frac{r_{E,i,t}}{w_{R,i,t}}\right)^{-1} \left(\frac{\beta}{\gamma}\frac{w_{R,i,t}}{w_{NR,i,t}} + \left(1 + \frac{\beta}{\gamma}\frac{w_{R,i,t}}{w_{NR,i,t}}\right)\left(\frac{r_{E,i,t}}{w_{R,i,t}}\right)^{\sigma-1}\right)^{-1}, \tag{4}$$

where $w_{i,t}L_{i,t} = w_{R,i,t}L_{R,i,t} + w_{NR,i,t}L_{NR,i,t}$ *is the total wage bill.*

The expression for the labor share of income provides a direct test of the substitutability between electric capital and routine tasks: if $\sigma > 1$, the labor share of income decreases as electric capital becomes cheaper; if $\sigma = 1$, the labor share is independent of the rental rate of electrical machinery; and if $\sigma < 1$, the labor share of income increases as electric capital becomes cheaper. The model also predicts that labor productivity and capital intensity increase as electric capital becomes cheaper. These three predictions characterize the labor-saving aspect of technology adoption.

For simplicity, this paper studies only the implications of the production function in partial equilibrium. Household preferences, labor supply, and the ensuing General Equilibrium properties do not alter equations (2-4). The interested reader is referred to Morin (2014).[23]

To translate the predictions (2-4) into regression equations, I log-linearize the expressions. The linearization does not identify the parameter σ but can recover the sign of $\sigma - 1$ with the expression for the labor share of revenue.[24] Two further difficulties arise in the context of electricity. First, the relative rental rate $r_{E,j,t}/w_{j,t}$ of electrical machinery is unobserved and I use the price of electricity in cents per kilowatt-hour as a proxy, which implies measurement

[23] On the other hand, the implications for output or employment in General Equilibrium depend crucially on the household preferences and labor market structure. Without labor market frictions, employment is constant and output increases as a result of technology adoption. With labor market frictions, such as a retraining cost, the substitution of capital for labor reduces employment for the duration of retraining.

[24] Even in the non-linear expression, σ is difficult to identify because the rental rate of electrical machinery $r_{E,i,t}$ is unobserved and approximated with the price of electricity $p_{E,k,t}$.

error and an attenuation bias toward zero.[25] Second, the average price of electricity at the plant-level is far from the marginal price: several forms of fixed costs (see Appendix A.2) introduce measurement error in the price of electricity paid by small concrete plants. Fixed costs lose importance when considering a larger entity such as the state, whose average price of electricity should be closer to the marginal price. The preferred measure of the price of electricity is the state-level average price from the Census of Electric Light and Power Stations for 1927 and 1937.[26] This measure minimizes the importance of fixed costs, making the average price closer to marginal price, and is close to the price of electricity paid by industrial users, since power stations sold on average 69% of their current to industrial consumers.[27]

Plants or states may also have unobserved characteristics, such as managerial ability or skill endowment. To abstract from these effects, I difference out these fixed effects by using changes across time as dependent variables. The regression equations for the predictions on ratio variables are:

$$\Delta \log \frac{w_{i,t} L_{i,t}}{p_{i,t} Y_{i,t}} = constant + a\, \Delta \log \left(p_{E,k,t}\right) + error, \tag{5}$$

$$\Delta \log \frac{Y_{i,t}}{L_{i,t}} = constant + b\, \Delta \log \left(p_{E,k,t}\right) + error, \tag{6}$$

$$\Delta \log \frac{K_{E,i,t}}{L_{i,t}} = constant + c\, \Delta \log \left(p_{E,k,t}\right) + error, \tag{7}$$

where i indexes plants, k indexes states, $w_{i,t}L_{i,t}$ is the aggregate wage-bill at the plant-level, $p_{i,t}Y_{i,t}$ is the output value at the plant-level, $p_{E,k,t}$ is the change in the price of electricity at the state-level, $Y_{i,t}/L_{i,t}$ is labor quantity productivity in tons of concrete, $L_{i,t}$ is employment, and $K_{E,i,t}/L_{i,t}$ is electrical intensity at the plant-level (the horsepower of electric motors per worker). The theory predicts $a > 0$, $b < 0$, and $c < -1$: if $\sigma > 1$, a decrease in the price

[25] The usage cost of electricity has two components: the price of electricity in kilowatt-hours and the rental rate of an electric motor. Regional variation in the usage costs stems mostly from the price of electricity because the rental rate of electric motors is likely to be the same for all regions. The rental rate of an electric motor has three components: the interest rate, the price of investment, and the depreciation rate. Each of these components should have similar values across regions: the interest rate was set by the Federal Reserve for all regions and the electrical machinery industry was concentrated in five states which served a national market with similar investment prices and depreciation rates.

[26] Stigler and Friedland (1962) used this measure to assess the effect of regulation on electricity prices. I have been unable to find other sources for the price of electricity at the state-level during this period.

[27] Census of Electric Light and Power Stations, 1927, page 51.

of electricity causes a decrease in the labor share of income, an increase in productivity, and an increase in electrical intensity.[28] These predictions characterize the labor-saving aspect of electrical machinery.

3.2 Qualitative predictions

Aside from the core regressions above that inform on the labor-saving aspect of electrical technology, this paper runs a further set of regressions to test the margin of adjustment: whether firms respond to cheaper electricity prices by reducing employment or increasing demand. The model is silent on this response: firms make zero profits, are indifferent about the scale of production, and it is the demand side of the market that determines the level of production and employment. This test disentangles technological unemployment from the Luddite fallacy. On the one hand, the supporters of the Luddite fallacy assume that firms pass cheaper electricity prices onto their output prices and that demand for output is sufficiently elastic. Then consumers increase demand and plants produce more output for the same level of employment. On the other hand, the supporters of technological unemployment argue that firms do not pass through cheaper electricity prices, or that demand for output is inelastic. Then demand may not increase quickly enough to offset productivity gains and firms decrease employment without increasing output.

The regression equations for testing the margin of adjustment are:

$$\begin{aligned}
\Delta \log p_{i,t} &= constant + a'\Delta \log \left(p_{E,k,t}\right) + error \\
\Delta \log p_{i,t}Y_{i,t} &= constant + c'\Delta \log \left(p_{E,k,t}\right) + error \\
\Delta \log Y_{i,t} &= constant + b'\Delta \log \left(p_{E,k,t}\right) + error \\
\Delta \log L_{i,t} &= constant + d'\Delta \log \left(p_{E,k,t}\right) + error
\end{aligned}$$

The technological unemployment argument is silent on a' and corresponds to $b' = 0$, $c' = 0$, and $d' > 0$: as electricity becomes cheaper, plants fire workers without increasing output. The

[28] The regressions use a nominal price with no deflator—deflating prices by a nation-wide price or wage index would affect the intercept of the regression and not the slope.

Luddite fallacy corresponds to $a' > 0$, $b' < 0$, $c' < 0$, and $d' = 0$: as electricity becomes cheaper, plants pass on cheaper electricity prices onto their consumers, which increases output and maintains employment.

4 Empirics

This section presents the identification strategy with the instrument for the change in electricity prices, discusses the baseline results of labor-saving technology, shows that firms adjusted to cheaper electricity prices by decreasing employment rather than increasing output, and argues for the validity of the instrument.

4.1 Instrument for the electricity supply curve

Estimating a regression of quantities on prices as in equations (5-7) raises concerns about endogeneity and is a challenge to identification: it is unclear whether the regression estimates the demand or supply equation. This paper is interested in the demand for electricity and requires an instrument that shifts the electricity supply curve and not the demand curve. This endogeneity should bias the estimation of the downward-sloping electricity demand curve toward the upward-sloping electricity supply curve. The coefficients should be further away from zero in Instrumental Variables (IV) compared to Ordinary Least Squares (OLS). A similar argument suggests that endogeneity also biases the coefficient on the labor share of income toward zero because the labor share of income is decreasing in the electric capital-labor ratio in the model.[29]

The identification strategy to deal with the endogeneity bias consists of two parts: using geography as an instrument for the change in the price of electricity and choosing the non-traded industry of concrete. The ideal test of technological explanation for labor market changes would be a random assignment of electricity prices across regions and an analysis of the subsequent

[29] Electric capital intensity is a strictly decreasing function of the relative rental rate of electrical machinery. By the implicit function theorem, the relative rental rate of electrical machinery is a decreasing function of electric capital intensity. The labor share of income is increasing in the relative rental rate of electrical machinery and therefore decreasing in electric capital intensity.

labor market decisions of firms. It is impossible to achieve this random allocation but one can use natural variation in the price of electricity depending on geography and the source of power. Electricity at this time came either from hydroelectric power or coal power. Hydroelectric power had high efficiency in 1930, extracting 90% of the potential energy of falling water, and had few opportunities for cost savings. Coal power had low efficiency, extracting 25% of the thermal energy of coal, and had many opportunities for cost savings.[30] The price of electricity decreased in regions with coal power, such as New Jersey, but less in regions with hydroelectric power, such as California. A state's initial loading on coal power is an instrument for the supply-side change in the price of electricity. Figure 3 shows the first-stage of the instrument at the state-level: states with initially larger dependence on coal power also had a decrease in the relative price of electricity. The F-statistic of the first-stage regression is high and above 20 in an unweighted regression that treats all states equally. The plant-level regressions put more weight on California than Arizona and consequently the F-statistic in the regressions decreases but is still above the usual confidence threshold of 10.

[FIGURE 3 HERE]

Given the natural variation in electricity prices, it could still be a problem if plants chose endogenously to locate in regions with cheaper electricity prices. The concrete industry provides a close approximation to the ideal random assignment of plants across regions because it is a local industry selling a non-traded good, as mentioned in Section 2. The location decision of concrete plants is orthogonal to the geography of the price of electricity, rules out geographical sorting, and strengthens the validity of the instrument. Measurements of labor market outcomes for the concrete industry provide a quasi-experiment to assess the causal effect of technical progress in electric utilities on downstream industries.

Four arguments support the validity of the geographical instrument. First, concrete plants do not sort geographically depending on the price of electricity: the concrete industry sells a non-traded product and locates near its customers. Second, the narrow scope of the concrete industry suggests that the instrument should affect electric utilities on the supply side of the electricity

[30] National Electric Light Association (1931, page 43).

market but not concrete plants on the demand side of the market. Third, the instrument is an initial level and the outcome variables are changes. Omitted variables in levels, such as the skill composition of the workforce or the density of the road network, would appear as a state or city fixed effect in a regression in levels and are differenced out in a regression in changes. Fourth, using ratios at the plant-level, such as labor productivity or the labor share of income, implies the absence of that plant-level shocks that affect the numerator and denominator similarly, such as TFP shocks, at least to a first-order approximation. The end of this section presents more empirical evidence supporting the validity of the instrument.

4.2 Results on labor share, productivity, and electric capital intensity

This section presents the evidence for $\sigma > 1$ and for the causal link between electricity and labor market ratio outcomes: the labor share of income, labor productivity, and electric capital intensity. Concrete plants facing cheaper electricity also reduced their labor share of income, increased labor quantity productivity, and increased electric capital intensity. The results are robust to several alternative specifications.

Table 3 shows the results in instrumental variables for the labor share of income. The decrease in the price of electricity caused a decrease in the labor share of income. The instrument is relevant with F-statistics above the threshold of 10. The regression of the labor share of revenue supports the crucial assumption in the model. The coefficient for the labor share is proportional to $\sigma - 1$: it should be positive under the assumption $\sigma > 1$ and zero under $\sigma = 1$. The results are robust to controlling for the 1920s housing boom and deposit suspensions within a 50-mile area of influence in GIS; to state-level controls (price of inputs, agricultural share in 1920 from the Census of Population, initial income from the Historical Statistics of the United States, union density, and a Herfindahl concentration index in 1929[31]), and firm-level controls (initial size and initial sales per worker). The standard errors in all plant-level regressions are clustered at the state-level and all variables are "winsorized" at the 2% level.

[TABLE 3 HERE]

[31] The Herfindahl index is the sum of squared market shares in 1929 of the 50 largest firms by state.

Table 4 shows that the decrease in the price of electricity caused an increase in labor productivity (tons of concrete per worker). Table 8 shows that the decrease in the price of electricity caused an increase in electric capital intensity. The IV regression of electrical intensity traces the demand curve and finds a negative coefficient: cheaper electricity induces more horsepower per worker. The theory predicts that the coefficients on electric capital-labor ratios should be smaller than -1 and the regressions confirm that prediction. These regressions in quantities suggest that the results are not due to deflation or other price channels. The results are also robust to the battery of geographic and plant-level controls. The coefficients are economically and statistically significant.

[TABLES 4-5 HERE]

Tables 6-8 show the results in reduced-form, which are in line with the IV estimates: initially higher coal reliance caused a decrease in the labor share of income, an increase in labor productivity, and an increase in electric capital intensity. The results are again robust to including state-level and plant-level controls.

[TABLES 6-8 HERE]

The coefficients may seem large but are reasonable compared to the distribution of changes over the period. The reduced-form coefficients suggest that technological convergence of coal states caused a decrease in the labor share of income of 10.9% over 6 years[32] (compared to an average decrease of 9.5%), an increase in productivity of 35.8% (compared to an average *decrease* of 30.2%), and an increase in electrical intensity of 39.2% (compared to an average increase of 38.9%). The predicted changes are in the range of 0.2 to 0.5 standard deviations of the distribution of changes over 1929 to 1935. These thought experiments assess the net contribution of electricity and holds constant other factors, such as the aggregate state of the economy that may induce a national-level downward shift in productivity.

[32] This number equals the reduced-form coefficient of -0.0252 in Table 6, multiplied by the average coal dependence share in the sample of 0.78, multiplied by 6 years in the period.

4.3 Margin of adjustment and technological unemployment

With confidence that electricity was a labor-saving technology, the paper now turns to the margin of adjustment and to the consequences of productivity improvements. First, Table 9 shows that cheaper electricity led to cheaper prices for concrete products: the elasticity is positive, statistically significant, and around 3. The F-statistics are close to or above 10. Concrete plants seem a relatively competitive industry that passed cheaper input prices onto consumers.

[TABLE 9 HERE]

Table 10 corroborates this view and suggests that cheaper electricity had no effect on plants' profits (defined as revenue minus wages, cost of materials, and energy). The electricity coefficient is not statistically significant and does not have a stable value across specifications. The assumption of perfect competition in the derivation of the formulas finds support in these results on price and profits.

[TABLE 10 HERE]

Table 11 shows the effect for revenue and Table 12 for quantity production: the estimate coefficients are not statistically significant, they are positive for revenue and negative for quantity, and the F-statistics are close to or above 10. The demand for concrete products seems inelastic and cheaper concrete prices did not lead to an increase in demand, as the supporters of the Luddite fallacy would predict.

[TABLES 11-12 HERE]

If cheaper electricity led to an increase in productivity with no effect on output, the only remaining channel is employment. Table 13 confirms the technological unemployment argument: concrete plants adjusted to cheaper electricity by decreasing employment. The coefficient is positive, statistically significant at the 1% level, and around 3. The reduced-form regression in Table 14 are in line with the IV results. Technological convergence in electricity prices caused a decrease in employment of 20.9% over 6 years[33] compared to the average decrease in the sample of 25.3%. Therefore the adoption of electricity may explain up to 83% of the decrease in employment in the sample of continuing concrete plants.

[TABLES 13-14 HERE]

Taken together, the available evidence from the concrete industry supports the view of technological unemployment instead of the Luddite fallacy: firms used cheaper electricity to decrease the labor share of income, increase productivity, increase capital intensity, and reduce employment, with no noticeable effect on output.

4.4 Instrument validity

To provide more support for the validity of the instrument, Table 15 suggests that the coal share instrument is orthogonal to plant-level characteristics and that the sample seems balanced on 1929 observables. Plants in coal states are initially similar to plants in hydroelectric states in many respects, such as initial productivity, employment, revenue, and labor share of income. The only statistical difference is in capital intensity: plants in coal states have less electric horsepower per worker than hydro states. These tables give confidence that the sample of continuing firms is balanced on observables and that electricity is the main difference between them.

[TABLE 15 HERE]

Another concern with the identification strategy is that cheap electricity could affect other local firms and increase the demand for concrete products. The absence of a statistically significant effect on quantity output and revenue in Tables (11-12) allays these concerns.

Using state-level geography as an instrument has the drawback that the instrument corresponds to inland regions as opposed to the coasts. Figure 5 shows that the mountains in the West and

[33] This number equals the reduced-form coefficient of -0.0435 in Table 14, multiplied by the average coal dependence share in the sample of 0.78, multiplied by 6 years in the period.

East Coast provide the altitude differentials necessary for hydroelectric power while the Great Plains need to use coal power. The need for falling water implies that hydroelectric power is close to the map of mountains in the United States. This correlation is a consequence of using geography as an instrument for the change in the price of electricity depending on the source of power.

[FIGURE 5 HERE]

If plants in the mountain regions are affected differently during the Depression, the differential treatment may invalidate the exclusion restriction of the Instrumental Variables approach. One possible violation of the exclusion restriction is that mountain regions have government programs for building dams, which would increase demand for concrete in regions with hydroelectric power compared to regions with coal power. This increase in demand may be met with the more adjustable factors, such as labor or materials. Nevertheless, the definition of the concrete industry excludes work done on site for dam construction and alleviates the concerns that concrete plants in hydroelectric regions are affected differentially. To be sure, Table 16 runs a falsification test with the materials share of revenue: electricity prices have no statistically significant effect.

[TABLE 16 HERE]

Table 17 also runs the regression for employment dropping plants within 50 miles of dams under construction: the point estimates for employment are similar with or without these counties. The first-stage F-statistic drops below the usual confidence threshold of 10—mainly because of California, the largest state with hydroelectric power. The results for the other variables are similar and unreported.

[TABLE 17 HERE]

Another threat to identification occurs if the share of coal in electric power generation reacts to changes in electricity demand and in aggregate demand. Figure 4 suggests that the change in coal capacity is uncorrelated with the change in housing construction over the 1920s. Furthermore, the correlation between steam share of power in 1917, 1922, and 1927 is always above 89%, suggesting that the steam share of power is a slow-moving variable that may be close to a geographic endowment.

[FIGURE 4 HERE]

5 Conclusion

This paper provides two contributions. First, it uses a plant-level dataset from the concrete industry during the 1930s, digitized for the first time for this project. This plant-level dataset has finer detail than the Census of Manufactures state-level publications for the concrete industry and allows a more precise test of technological unemployment by considering continuing plants and by excluding plants near dam construction. Second, the identification strategy uses a new instrument—a state's initial loading on the coal technology—to isolate the exogenous shift in the electricity supply curve. It finds that electricity was a labor-saving technology and that technological convergence in electric utilities caused an 11% decrease in the labor share of income, a 36% increase in labor productivity, and a 39% increase in electrical intensity over the period 1929-1935. These results imply that the elasticity of substitution between electricity and routine tasks is greater than 1. Some occupations may be more replaced by electrical machinery than others, such as the routine, dexterity-intensive occupations described by Gray (2013).

This paper also lends support to the view of technological unemployment during the Great Depression, whereby the adoption of labor-saving technology could be a source of unemployment, and against the Luddite fallacy, whereby the increase in productivity is offset by an increase in output with no job losses. The paper documents the margin of adjustment to the labor-saving technology: firms reacted to cheaper electricity by reducing the price of concrete products, with no effect on their profits. The demand for concrete does not seem sufficiently elastic and the growth in output was too weak to offset productivity gains, leading to a 21% loss of employment in the concrete industry. Technological convergence in electric utilities can explain up to 80% of job losses in the concrete industry during the Great Depression.

This paper also contributes to the recent debate on labor market changes since the 1980s: Berger (2012) attributed the emergence of jobless recoveries to the decline in unionization, whereas Jaimovich and Siu (2012) explained them with the adoption of Information and Communication Technologies, either directly with the substitution of computers for workers or indirectly with the ability to offshore jobs to developing countries. If we consider the similarities between computers and electricity (David, 1990) and bear in mind that offshoring was infeasible in the 1930s and unionization rates were increasing until the 1940s (Farber and Western, 2000), then this paper offers historical support for the channel of direct substitution of computers for workers in routine occupations.

This paper showed that the adoption of electricity caused a decrease in employment but was silent on the subsequent outcomes for these workers. Did displaced workers become chronically unemployed or were they able to find a job in another occupation? If they did find a new occupation, were they earning a higher or lower wage than before? An investigation of occupational change in the long-run is left for future research.

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A Appendix

A.1 Proofs

Proof of equations (2-4). This proof omits the plant index i. The firm maximizes intertemporal profits

$$\sum_{t=0}^{\infty} D_{0,t} \left(p_t A_t K_{NE,t}^{\alpha} L_{NR,t}^{\beta} \left(K_{E,t}^{\rho} + L_{R,t}^{\rho} \right)^{\frac{\gamma}{\rho}} - w_{NR,t} L_{NR,t} - w_{R,t} L_{R,t} - r_{NE,t} K_{NE,t} - r_{E,t} K_{E,t} \right),$$

where $\rho = (\sigma - 1)/\sigma$ and $D_{0,t}$ is the discount factor. The firm has no accumulation constraints on capital or labor and the intertemporal maximization problem collapses to a sequence of static maximization problems. Taking prices as given, the first-order conditions for profit-maximization are:

$$
\begin{aligned}
MPK_{NE,t} &= \frac{\alpha\, p_t\, Y_t}{K_{NE,t}} = r_{NE,t}, \\
MPL_{NR,t} &= \frac{\beta\, p_t\, Y_t}{L_{NR,t}} = w_{NR,t}, \\
MPK_{E,t} &= \gamma\, p_t\, Y_t\, L_{R,t}^{\rho-1}\, \left(K_{EI,t}^{\rho} + L_{R,t}^{\rho}\right)^{-1} = r_{E,t}, \\
MPL_{R,t} &= \gamma\, p_t\, Y_t\, L_{R,t}^{\rho-1}\, \left(K_{E,t}^{\rho} + L_{R,t}^{\rho}\right)^{-1} = w_{R,t},
\end{aligned}
$$

where MPF is the marginal product of factor F. The ratio of electric capital to routine tasks is:

$$\frac{K_{E,t}}{L_{R,t}} = \left(\frac{r_{E,t}}{w_{R,t}}\right)^{-\sigma}.$$

The labor share of income is increasing in the rental rate of electrical machinery:

$$\frac{w_t L_t}{p_t Y_t} = \frac{w_{NR,t} L_{NR,t}}{p_t Y_t} + \frac{w_{R,t} L_{R,t}}{p_t Y_t} = \beta + \gamma \left(1 + \left(\frac{K_{E,t}}{L_{R,t}}\right)^{\rho}\right)^{-1} = \beta + \gamma \left(1 + \left(\frac{r_{E,t}}{w_{R,t}}\right)^{1-\sigma}\right)^{-1}.$$

Labor productivity is decreasing in the rental rate of electrical machinery:

$$\frac{Y_t}{L_t} = \frac{w_t}{p_t} \left(\beta + \gamma \left(1 + \left(\frac{r_{E,t}}{w_{R,t}}\right)^{1-\sigma}\right)^{-1}\right)^{-1}$$

To compute electric capital intensity, first use the ratio of the marginal products to write the routine share of employment as:

$$\frac{L_{R,t}}{L_t} = \frac{L_{R,t}}{L_{NR,t} + L_{R,t}} = \left(1 + \frac{L_{NR,t}}{L_{R,t}}\right)^{-1} = \left(1 + \frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}} + \frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}}\left(\frac{r_{E,t}}{w_{R,t}}\right)^{1-\sigma}\right)^{-1}.$$

Then use this ratio to write electric capital intensity as a decreasing function of the rental rate of electrical machinery:

$$
\begin{aligned}
\frac{K_{E,t}}{L_t} = \frac{K_{E,t}}{L_{R,t}}\,\frac{L_{R,t}}{L_t} &= \left(\frac{r_{E,t}}{w_{R,t}}\right)^{-\sigma} \left(1 + \frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}} + \frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}}\left(\frac{r_{E,t}}{w_{R,t}}\right)^{1-\sigma}\right)^{-1}, \\
&= \left(\frac{r_{E,t}}{w_{R,t}}\right)^{-1} \left(\frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}} + \left(1 + \frac{\beta}{\gamma}\frac{w_{R,t}}{w_{NR,t}}\right)\left(\frac{r_{E,t}}{w_{R,t}}\right)^{\sigma-1}\right)^{-1}.
\end{aligned}
$$

A.2 More details on electricity

Other measures of the price of electricity Other measures of the price of electricity at the city-level or state-level exist during this period but they are inferior to the state-level price of electricity used in the baseline regressions.

At the state-level, the Census of Electric Light and Power Stations in 1927 and 1937 reports the price of electricity by municipal utilities but these concern a small market (5% of total kilowatt-hours).[34] The Census of Electric Light and Power Stations also published the price of electricity from both public and private utilities to industrial consumers, split by "small" (retail) and "large" (wholesale), but the "wholesale" numbers exist only half of the states to prevent disclosure of establishment information.

At the city-level, the price of electricity paid by ice plants (Ziebarth, 2011) covers cities that coincide with only 200 concrete plants. Another source, the city-level price of electricity for residential consumers for a typical bill of 25, 100, or 250 kilowatt-hours (Federal Power Commission, 1937) is a survey with measurement error due to retrospective questions asked in 1936, concerns residential consumers instead of industrial consumers, and has a significantly lower amount than the average demand by concrete plants in 1929 (1400 kilowatt-hours per month for concrete plants versus 250 kilowatt-hours for residential consumers), and they are also on different rate schedules, detailed below. To the best of my knowledge, there are no other measures for the price of electricity that are disaggregated geographically over this period.

At the plant-level, the price of electricity is plagued with fixed costs: a Paasche index of the change in the price of electricity at the plant-level aggregated at the state-level is *negatively* related to the change in the state-level price of electricity, but it should be positively related.

Pricing of electricity and rate schedules of electric utilities Electric utilities offered many rate schedules, detailed by the Federal Power Commission in a published glossary in 1936. All rates have a component of capacity, in kilowatts or horsepower, and of energy, in kilowatt-hours or Joules.

An electric bill consists of three types of charges: a customer charge, a demand charge, and an energy charge. The Federal Power Commission defines

[34] Census of Electric Light and Power Stations, 1927, page 71.

- "customer charge" or "service charge" as "a component part of a rate schedule providing that a customer must pay a certain definite sum in a specified period (usually 1 month) without regard to the consumption of energy or the demand, for which he can use no energy or demand",
- "demand charge" as "a component part of a rate schedule which provides for a charge based upon the customer's demand or equivalent, without regard to the consumption of energy"
- "energy charge" as "a component part of a rate schedule that provides for a charge based upon the amount of energy consumed."

In short, the customer pays a service charge for connecting to the grid, a demand charge for the right to use a given capacity from the grid, and an energy charge for consumption of electricity.

Most rate schedules also define "maximum demand," which is often the aggregate capacity of electric appliances commonly used. For example, a plant may have a primary motor and a stand-by motor, each with a capacity of 100 kW. The plant may normally use only the primary motor and contracts for a maximum demand of 100 kW. If the plant happens to use both motors at the same time, it will have to pay a higher price for using more capacity than the maximum demand.

Electric utilities offered up to eight different schedules depending on the use of fixed costs. Some examples are the flat rate, the straight line meter rate, the flat demand rate. See the glossary by the Federal Power Commission for more details.

A.3 Details on the Census of manufactures for the concrete industry

Matching across years I matched plants between years 1929 and 1935 according to a similar procedure as Bresnahan and Raff (1991). Some plants sent two schedules to the Census Bureau, such as one by the plant and another by the general office; on two occasions, I aggregated them into a new plant by either averaging their responses if the two schedules covered the same period of operation, or by summing their results if they covered different periods.

I considered that two plants were a match if:

1. one plant is from 1929 and the other from 1935,

2. the two plants are located in the same state, county, and city,
3. one of the following conditions hold:
   (a) the name fields coincide (name of plant, name of owner, or their change) and the location fields coincide (same street location in both years, or the street location in a year coincides with the general office location in another year),
   (b) the name fields coincide, one of the plants did not report a street location, and they are the only plants in that state, county, and city,
4. no other plants match criteria (1-3).

As an example of condition 2, I considered small cities included in larger cities to be the same, such as Flushing and New York. I also considered nearby cities to be the same, such as Edina and Minneapolis, since concrete plants sometimes reported the location of the plant and sometimes the post office address of the general office.

As an example of condition 3 (a), it is verified between a plant in 1935 with name "Gehirs" and address "23 Conklin St," and a plant in 1929 with owner "Gehirs" and address "Conklin street and Liberty Avenue."

As an example of condition 4, if two plants in Rockford, Illinois, share the name "Rockford plant" in 1929, then none is matched to the "Rockford plant" in 1935.

This procedure produces 630 plants merged between 1929 and 1935. Out of the 2,435 concrete plants operating in 1929, 74% exited the market, representing 54% of value and 58% of employment. Out of the 1,108 concrete plants operating in 1935, a third entered the market.

The schedules changed slightly across plants. Some concrete plants in 1929 filled a schedule for the Census of Mines and Quarries, which omitted questions about electricity consumption and the quantity of output. For the quantity of output, I only considered products reported with a unit of tons, converting ready-mix concrete from cubic yards to tons with a factor of 2.02817. I set the weight of products to a missing value if they represented less than 50% of the value of products.

Data for the Census of Manufactures in other years The schedules from the Census of Manufactures before 1929 and after 1935 did not survive. The Census Bureau used them to compile information for the Statistical Abstracts and other publications of the manufacturing industry.

Page 88 of Preliminary Inventory 161[35] mentions that "Most of the manufacturing schedules—but not those described immediately below and in entries 321, 322, and 324—have been disposed of by authorization of Congress." The surviving years for the Census of Manufactures are 1810-1885 and 1929-1935.

I searched for earlier or later schedules extensively and found only one surviving schedule from 1925, for the Crow Indian Mill in Colorado and kept at the National Archives in Denver, and one surviving schedule from 1939, for a German-owned company and the German American Bund that was seized during World War II.

The schedules for the 1947 Census of Manufactures were transferred to non-safety microfilm, are disintegrating, and are "unavailable to researchers [because of] preservation issues and concerns."[36] The later data for the Census of Manufactures starts in 1972 at the College Park branch of the National Archives and has restricted access.[37]

Categories of employment The Census asked about two categories of employment, wage-earners and salaried workers, described in detail below. Wage-earners are present in all years and represent around 90% of employment. Officers of the corporation were sometimes reported on a special administrative schedule that is absent from the Census of Manufactures.

In 1929, the Census seems to have included engineers and other technical employees as wage-earners. In 1935, technical employees had a separate category. This paper considers all categories of employment, excluding proprietors (who had no salary) and salaried officers (who were sometimes reported on a different form).

The details of employment categories suggest that the two types of employment are different from skilled/unskilled and from routine/nonroutine occupations.

- Categories of employment in 1929:
  - Proprietor or firm members
  - Principal officers of corporations
  - "Managers, superintendents, and other responsible administrative employees; foremen and overseers who devote all or the greater part of their time to supervisory duties; clerks, stenographers, bookkeepers, and other clerical employees on salary."

[35] This document is unpublished and exists physically at the National Archives and Records Administration. It serves as a reference tool for researchers to know the location of the records to request. It was compiled by Katherine H. Davidson and Charlotte M. Ashby.

[36] Electronic correspondence with the National Archives at College Park, Maryland.

[37] Telephone discussion with the National Archives at College Park, Maryland.

  - Wage-earners: "Skilled and unskilled workers of all classes, including engineers, firemen, watchmen, packers; also foremen and overseers in minor positions who perform work similar to that done by the employees under their supervision."

- Categories of employment in 1935:

  - Proprietor or firm members
  - Salaried officers of the corporation
  - Supervisory employees: "managers, superintendents, and other responsible administrative employees (including plant foremen whose duties are primarily supervisory but *not* including foremen and overseers in minor positions who perform work similar to that of the employees under their supervision"
  - Technical employees: "trained technicians, such as chemists, electrical and mechanical engineers, designers, who hold responsible positions requiring technical training and whose supervisory duties, if any, are only incidental"
  - Clerical employees: "clerks, stenographers, bookkeepers, timekeepers, and other clerical employees (including laboratory assistants, draftsmen), whether in the office or in the factory"
  - Wage-earners: "all time and piece workers employed in the plant (including the power plant and the maintenance, shipping, warehousing, and other departments) covered by this report, not including employees reported above. Include here working foremen and gang and straw bosses, but nor foremen whose duties are primarily supervisory."

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Tables and Figures

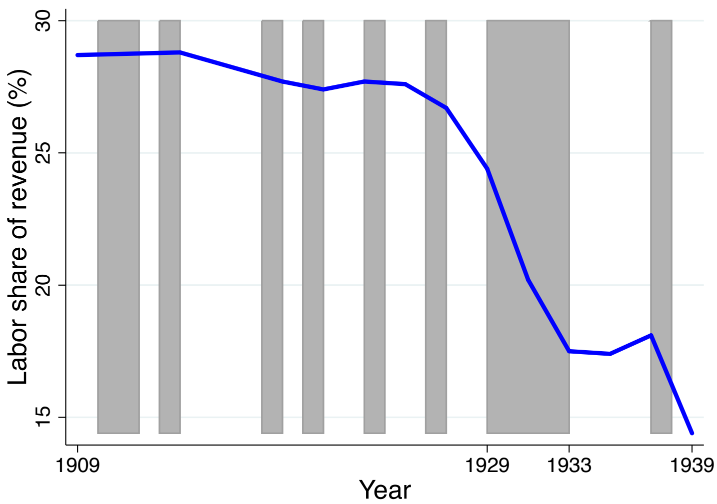
Table 1: Summary statistics for the concrete industry in 1929.

Number of plants	630
Employment of all plants	7978
Average employment per plant	13
Electricity share of revenue	1.3%
Electricity and fuel share of revenue	2.4%
Horsepower of electric motors	44

Table 2: Summary statistics for the change between 1929 and 1935.

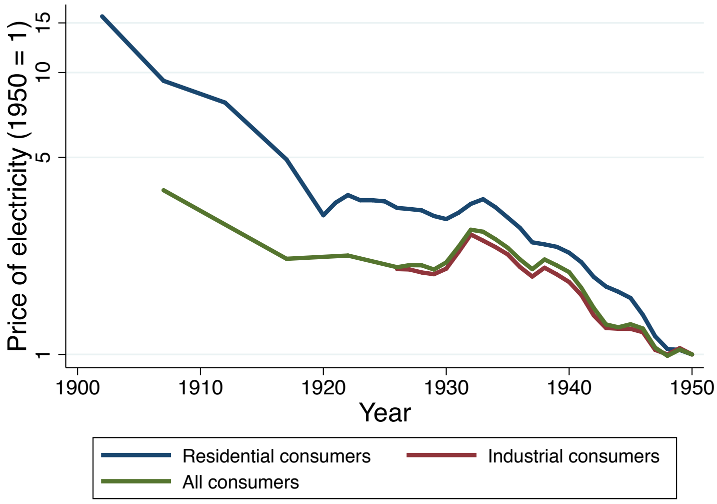
Change from 1929 to 1935 (log-points, annualized)	Mean	S.d.
Revenue	-0.09	0.15
Labor share	-0.02	0.09
Employment	-0.04	0.13
State-level cost of electricity	-0.02	0.01
Horsepower of electric motors	0.01	0.13

Figure 1: The decline in the labor share of revenue of the concrete industry accelerated during the Great Depression.



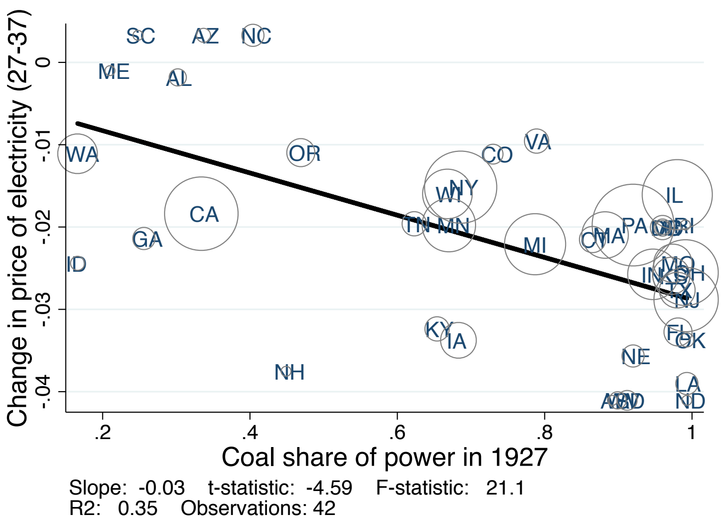
Notes: wage bill divided by revenue every two years from 1909 to 1939, from the publication Census of Manufactures for the year 1939. Shaded areas are NBER recessions.

Figure 2: The real price of electricity decreased exponentially in the first half of the 20th century.



Notes: The price of electricity is in cents per kilowatt-hour from the Historical Statistics of the United States, series Db234, Db235, and Db237. The price deflator is the consumer price index from the BLS, series Cc1. The rate of decrease of the price of electricity for residential consumers is 5.8%.

Figure 3: First-stage regression: an initially higher share of coal in power generation in 1927 causes a subsequent decrease in the relative price of electricity.



Notes: Larger circles represent states with more plants but the regression has the same weight for all states.

Table 3: The decrease in the price of electricity caused a decrease in the labor share of revenue.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ labor share		
Δ price of electricity	1.969**	2.949**	1.883**	2.277**	1.714**
	(0.947)	(1.348)	(0.850)	(0.982)	(0.856)
Δ price of cement		-0.0205			
		(0.0316)			
Farm share in 1920		-0.143**			
		(0.0581)			
Log-personal income in 1929		-0.102***			
		(0.0389)			
Δ housing in 1920s			-0.00671		
			(0.0153)		
bank suspensions			0.00114		
			(0.0462)		
initial size (plant)				0.00562*	
				(0.00325)	
initial productivity (plant)				0.0654***	
				(0.00550)	
unionization					-0.00164*
					(0.000937)
Herfindahl index					-0.00862
					(0.0465)
Observations	621	576	621	621	618
First-stage F-statistic	11.14	9.771	12.51	11.19	11.90
Number of states/clusters	42	32	42	42	41

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 4: The decrease in the price of electricity caused an increase in labor (quantity) productivity.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ labor productivity		
Δ price of electricity	-5.648***	-7.343***	-5.224***	-5.827***	-5.531***
	(2.047)	(2.086)	(1.882)	(1.996)	(1.934)
Δ price of cement		0.0775			
		(0.0559)			
Farm share in 1920		0.283**			
		(0.135)			
Log-personal income in 1929		0.159*			
		(0.0836)			
Δ housing in 1920s			0.0368		
			(0.0299)		
bank suspensions			-0.00460		
			(0.0797)		
initial size (plant)				0.00682	
				(0.00595)	
initial productivity (plant)				-0.0845***	
				(0.0108)	
unionization					0.00134
					(0.00119)
Herfindahl index					0.0760
					(0.0750)
Observations	483	445	483	483	481
First-stage F-statistic	12.01	12.00	13.24	12.09	12.54
Number of states/clusters	40	31	40	40	39

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 5: The decrease in the price of electricity caused an increase in electric capital intensity.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ electric capital intensity		
Δ price of electricity	-6.959***	-6.623***	-5.585***	-6.692***	-5.838***
	(2.114)	(1.587)	(1.424)	(2.185)	(1.544)
Δ price of cement		0.0627*			
		(0.0374)			
Farm share in 1920		0.0465			
		(0.139)			
Log-personal income in 1929		0.164**			
		(0.0681)			
Δ housing in 1920s			0.113***		
			(0.0325)		
bank suspensions			-0.0638		
			(0.0893)		
initial size (plant)				0.0535***	
				(0.00568)	
initial productivity (plant)				-0.0365**	
				(0.0154)	
unionization					0.00378**
					(0.00149)
Herfindahl index					-0.314***
					(0.107)
Observations	475	444	475	475	472
First-stage F-statistic	11.85	10.53	13.32	11.88	12.77
Number of states/clusters	39	32	39	39	38

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 6: Reduced-form results for the labor share: initially higher coal reliance caused a decrease in the labor share of revenue.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ labor share		
coal share of power in 1927	-0.0252**	-0.0353**	-0.0261*	-0.0291**	-0.0233**
	(0.0117)	(0.0149)	(0.0130)	(0.0128)	(0.0115)
Δ price of cement		0.00767			
		(0.0342)			
Farm share in 1920		-0.107			
		(0.0716)			
Log-personal income in 1929		-0.0578			
		(0.0373)			
Δ housing in 1920s			0.00684		
			(0.0131)		
bank suspensions			-0.00536		
			(0.0476)		
initial size (plant)				0.00516	
				(0.00316)	
initial productivity (plant)				0.0663***	
				(0.00580)	
unionization					-0.00125
					(0.000810)
Herfindahl index					-0.0297
					(0.0543)
Observations	621	576	621	621	618
R-squared	0.005	0.011	0.006	0.134	0.010
Number of states/clusters	42	32	42	42	41

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 7: Reduced-form results for labor productivity: initially higher coal reliance caused an increase in labor (quantity) productivity.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ labor productivity		
coal share of power in 1927	0.0738***	0.0958***	0.0733***	0.0760***	0.0764***
	(0.0183)	(0.0173)	(0.0201)	(0.0167)	(0.0177)
Δ price of cement		0.00506			
		(0.0298)			
Farm share in 1920		0.233***			
		(0.0782)			
Log-personal income in 1929		0.0672*			
		(0.0372)			
Δ housing in 1920s			-0.00191		
			(0.0275)		
bank suspensions			0.0202		
			(0.0791)		
initial size (plant)				0.00840	
				(0.00562)	
initial productivity (plant)				-0.0862***	
				(0.0118)	
unionization					0.000558
					(0.000930)
Herfindahl index					0.144
					(0.0937)
Observations	483	445	483	483	481
R-squared	0.015	0.031	0.015	0.105	0.020
Number of states/clusters	40	31	40	40	39

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 8: Reduced-form results for capital intensity: initially higher coal reliance caused an increase in electric capital intensity.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ electric capital intensity		
coal share of power in 1927	0.0925**	0.0828***	0.0811**	0.0887**	0.0845**
	(0.0355)	(0.0257)	(0.0303)	(0.0345)	(0.0324)
Δ price of cement		0.00178			
		(0.0430)			
Farm share in 1920		-0.0357			
		(0.121)			
Log-personal income in 1929		0.0668			
		(0.0620)			
Δ housing in 1920s			0.0720**		
			(0.0322)		
bank suspensions			-0.0466		
			(0.0803)		
initial size (plant)				0.0550***	
				(0.00564)	
initial productivity (plant)				-0.0363**	
				(0.0157)	
unionization					0.00171
					(0.00148)
Herfindahl index					-0.244***
					(0.0813)
Observations	475	444	475	475	472
R-squared	0.022	0.043	0.036	0.201	0.039
Number of states/clusters	39	32	39	39	38

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 9: The decrease in the price of electricity caused cheaper output prices.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ output price		
Δ price of electricity	3.540**	3.704**	3.275**	3.500**	3.448**
	(1.502)	(1.550)	(1.509)	(1.499)	(1.456)
Δ price of cement		-0.0774***			
		(0.0274)			
Farm share in 1920		-0.0789			
		(0.0893)			
Log-personal income in 1929		-0.0660			
		(0.0580)			
Δ housing in 1920s			-0.0414**		
			(0.0184)		
bank suspensions			0.0879*		
			(0.0516)		
initial size (plant)				-0.00756*	
				(0.00406)	
initial productivity (plant)				-0.0116*	
				(0.00686)	
unionization					-0.000385
					(0.000958)
Herfindahl index					0.00673
					(0.0554)
Observations	454	421	454	453	452
First-stage F-statistic	10.11	9.615	10.90	10.29	10.60
Number of states/clusters	40	31	40	40	39

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 10: The decrease in the price of electricity had no statistically significant effect on the profits of concrete plants.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ profits		
Δ price of electricity	2.198	2.046	0.543	0.434	2.859
	(1.960)	(2.703)	(1.916)	(2.175)	(1.973)
Δ price of cement		-0.0340			
		(0.0669)			
Farm share in 1920		0.0458			
		(0.141)			
Log-personal income in 1929		0.00774			
		(0.0808)			
Δ housing in 1920s			-0.100***		
			(0.0305)		
bank suspensions			-0.0709		
			(0.0848)		
initial size (plant)				-0.0846***	
				(0.00594)	
initial productivity (plant)				-0.156***	
				(0.0164)	
unionization					0.00512**
					(0.00222)
Herfindahl index					0.118
					(0.0924)
Observations	602	559	602	600	599
First-stage F-statistic	10.98	9.233	12.34	10.99	11.91
Number of states/clusters	41	32	41	41	40

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11: The decrease in the price of electricity had no statistically significant effect on revenue.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ revenue		
Δ price of electricity	2.160	2.779	0.904	1.553	2.349
	(1.467)	(2.119)	(1.347)	(1.081)	(1.448)
Δ price of cement		-0.0360			
		(0.0502)			
Farm share in 1920		-0.0647			
		(0.119)			
Log-personal income in 1929		-0.0654			
		(0.0727)			
Δ housing in 1920s			-0.0867***		
			(0.0180)		
bank suspensions			-0.0257		
			(0.0579)		
initial size (plant)				-0.0682***	
				(0.00410)	
initial productivity (plant)				-0.0780***	
				(0.0140)	
unionization					0.00189
					(0.00160)
Herfindahl index					0.112
					(0.0695)
Observations	630	585	630	628	627
First-stage F-statistic	11.19	9.699	12.50	11.25	11.98
Number of states/clusters	42	32	42	42	41

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 12: The decrease in the price of electricity has no statistically significant effect on quantity output.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ output		
Δ price of electricity	-1.936	-3.035	-2.417	-1.997	-1.823
	(2.806)	(2.743)	(2.487)	(2.435)	(2.841)
Δ price of cement		0.0427			
		(0.0554)			
Farm share in 1920		0.104			
		(0.103)			
Log-personal income in 1929		0.0329			
		(0.0723)			
Δ housing in 1920s			-0.0393		
			(0.0252)		
bank suspensions			0.0129		
			(0.0911)		
initial size (plant)				-0.0599***	
				(0.00581)	
initial productivity (plant)				-0.0847***	
				(0.0134)	
unionization					0.00289*
					(0.00160)
Herfindahl index					0.146
					(0.0994)
Observations	454	421	454	453	452
First-stage F-statistic	10.11	9.615	10.90	10.29	10.60
Number of states/clusters	40	31	40	40	39

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 13: The decrease in the price of electricity caused a decrease in employment.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ employment		
Δ price of electricity	3.405***	4.307***	2.688***	3.005**	3.276***
	(1.226)	(1.601)	(0.958)	(1.187)	(1.174)
Δ price of cement		-0.0567*			
		(0.0321)			
Farm share in 1920		-0.162			
		(0.109)			
Log-personal income in 1929		-0.131**			
		(0.0582)			
Δ housing in 1920s			-0.0574**		
			(0.0242)		
bank suspensions			0.0170		
			(0.0614)		
initial size (plant)				-0.0618***	
				(0.00339)	
initial productivity (plant)				0.0135	
				(0.0110)	
unionization					9.21e-05
					(0.00173)
Herfindahl index					0.113**
					(0.0476)
Observations	621	576	621	621	618
First-stage F-statistic	11.14	9.771	12.51	11.19	11.90
Number of states/clusters	42	32	42	42	41

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 14: Reduced-form results for employment: initially higher coal reliance caused a decrease in employment.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ employment		
coal share of power in 1927	-0.0435***	-0.0515***	-0.0373**	-0.0384***	-0.0446***
	(0.0137)	(0.0139)	(0.0140)	(0.0100)	(0.0148)
Δ price of cement		-0.0156			
		(0.0287)			
Farm share in 1920		-0.110*			
		(0.0585)			
Log-personal income in 1929		-0.0659**			
		(0.0275)			
Δ housing in 1920s			-0.0381*		
			(0.0192)		
bank suspensions			0.00771		
			(0.0549)		
initial size (plant)				-0.0624***	
				(0.00333)	
initial productivity (plant)				0.0147	
				(0.0106)	
unionization					0.000825
					(0.00135)
Herfindahl index					0.0732
					(0.0481)
Observations	621	576	621	621	618
R-squared	0.007	0.010	0.012	0.306	0.010
Number of states/clusters	42	32	42	42	41

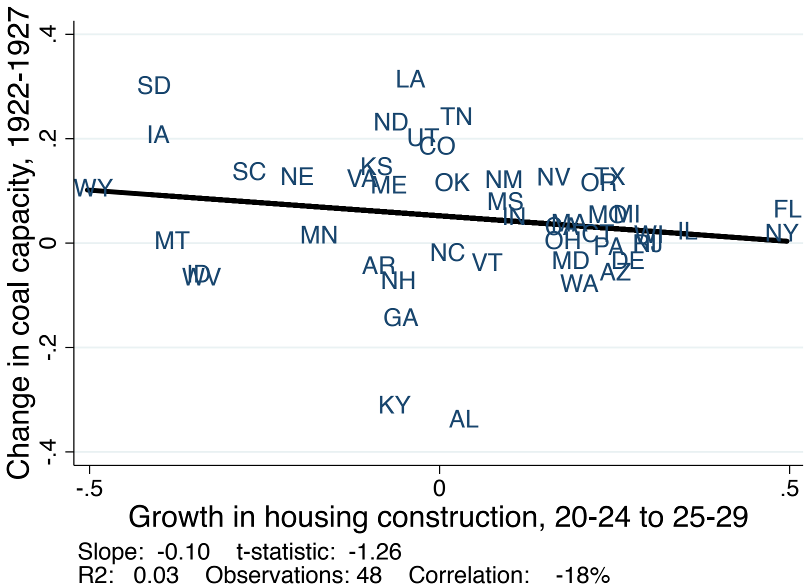
Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 15: The sample is balanced on observables, except for electricity usage.

Dependent variable in 1929	(1) labor productivity	(2) employment	(3) revenue	(4) electric capital intensity	(5) labor share
coal share of power in 1927	0.197	0.0612	0.116	-0.314*	0.00261
	(0.172)	(0.183)	(0.208)	(0.156)	(0.0182)
Constant	5.746***	1.859***	10.33***	1.307***	0.295***
	(0.133)	(0.130)	(0.160)	(0.134)	(0.0146)
Observations	569	628	630	563	630
R-squared	0.003	0.000	0.001	0.007	0.000

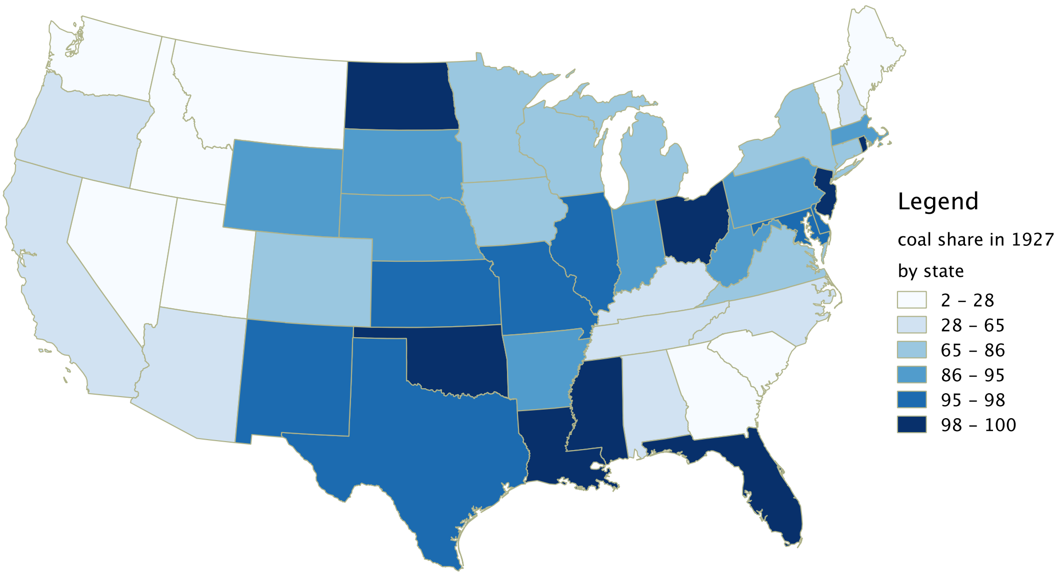
Notes: All dependent variables in logarithms, except for the labor share. Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Figure 4: The change in coal capacity between 1922 and 1927 is uncorrelated with the growth in housing construction from 190-1924 to 1925-1929.



Notes: housing is the number of dwellings built over each quinquennium (1925-1929 or 1920-1924), kindly provided by Kimbrough and Snowden (2007).

Figure 5: Map of the share of coal power in 1927.



Notes: Census of Electric Light and Power Stations (1927), page 60.

Table 16: Falsification test: the decrease in the price of electricity had no effect on the materials share of revenue.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δmaterials share		
Δ price of electricity	1.085	0.640	1.178	1.156	0.854
	(0.773)	(1.000)	(0.822)	(0.795)	(0.670)
Δ price of cement		-0.0132			
		(0.0123)			
Farm share in 1920		0.0338			
		(0.0504)			
Log-personal income in 1929		-0.00411			
		(0.0298)			
Δ housing in 1920s			-0.00163		
			(0.0118)		
bank suspensions			0.0326		
			(0.0465)		
initial size (plant)				0.00933***	
				(0.00285)	
initial productivity (plant)				0.00422	
				(0.00535)	
unionization					-0.00102**
					(0.000468)
Herfindahl index					0.0302
					(0.0247)
Observations	599	557	599	598	596
First-stage F-statistic	10.61	9.318	11.91	10.73	11.40
Number of states/clusters	42	32	42	42	41

Notes: Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 17: Robustness check: the IV point estimates for employment are similar dropping counties near dam construction.

	(1)	(2)	(3)	(4)	(5)
Dependent variable			Δ employment		
Δ price of electricity	3.001*	5.131	2.178*	3.248**	2.920*
	(1.625)	(3.603)	(1.204)	(1.619)	(1.556)
Δ price of cement		-0.0535			
		(0.0441)			
Farm share in 1920		-0.153			
		(0.167)			
Log-personal income in 1929		-0.147			
		(0.107)			
Δ housing in 1920s			-0.0499*		
			(0.0255)		
bank suspensions			0.0305		
			(0.0907)		
initial size (plant)				-0.0630***	
				(0.00390)	
initial productivity (plant)				0.0142	
				(0.0129)	
unionization					0.000485
					(0.00211)
Herfindahl index					0.117**
					(0.0513)
Observations	512	479	512	512	509
First-stage F-statistic	7.267	3.486	9.176	7.200	8.060
Number of states/clusters	38	30	38	38	37

Notes: Latitude and longitude by city are from Gaslamp Media, which "compiled from a city/county/state database and geocoded with Google Maps." The list of counties with dam construction is from Hay (1991) for dams completed between 1930 and 1940. The latitude and longitude of a county with dam construction is the average of all cities in that county. The closest distance from county X to a dam under construction is the minimum Haversine distance from all cities in county X to all cities in counties with dam construction.Constant omitted. Clustered standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1